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TESTS OF DDT AGAINST THE INSECT PESTS OF STORED SEED, GRAIN, AND MILLED CEREAL PRODUCTS

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In experiments conducted at Hutchinson and Manhattan, Kans., during 1944 DDT appeared to be highly effective against insects that attack stored seed, grain, and milled cereal products. In concentrated form, in admixture with carrier dusts, or as a toxicant in oil-base sprays, it may constitute a valuable addition to the insecticides which are effective for combating these pests. Miscellaneous uses for this chemical are briefly discussed.

Tests with Seed Wheat

In the course of an investigation of inert and chemical dusts for the protection of seed from insect attack, DDT was tested and found to be highly efficient. Inert dusts protect seed from attack because they kill the insects by desiccation. Such dusts are ineffective, however, if the moisture content of the seed is much over 12.5 percent. Chemical dusts kill by contact or by poisoning due to the ingestion of the dust particles; hence their action is independent of the moisture content of the seed.

Experimental work was undertaken with seed wheat of 12 percent moisture content. To 500-gram samples 0.05, 0.025, and 0.005 percent by weight of technical DDT was added. The samples were placed in glass jars, together with adults or larvae of 8 species of seed-infesting insects, one species to a jar. The jars were examined weekly to determine the effectiveness of the treatments. At the end of the first week all three dosages gave a complete kill of adults of the rice weevil (Sitophilus oryza (L.)), the confused flour beetle (Tribolium confusum Duv.), the red flour beetle (T. castaneum (Hbst.)), the lesser grain borer (Rhizopertha dominica (F.)), the saw-toothed grain beetle (Oryzaephilus surinamensis (L.)), and the larvae of the Indian-meal moth (Plodia interpunctella (Hbn.)). A complete kill of adults of the granary weevil (Sitophilus granarius (L.)) was obtained at the end of the first week with the 0.05 percent dosage and with all dosages at the end of 2 weeks. The larvae of the cadelle (Tenebroides mauritanicus (L.)) were more resistant than larvae of the other species. At the end of 5 weeks 20, 48, and 76 percent were still alive in the jars treated with the 0.05, 0.025, and 0.005 percent dosages.

Another series of tests was conducted with a 3 percent DDT-pyrophyllite dust. The results, which are given in table 1, indicate that this dust is highly effective at 15 p.p.m. of DDT. No immature forms of the insects completed their development. The use of the DDT-pyrophyllite mixture appeared to be more advantageous than the undiluted form used in the previous experiments, probably because the mixture provided better coverage of the seed and distribution of the DDT.

Table 1.--Efficiency of 3 percent DDT-pyrophyllite in protecting seed wheat from insect attack 1/

Concentration of DDT in wheat	Percent mortality after— 1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks
P.p.m.			Rice weevil			
3	52					
15	100					
30	100					
0 2/	2					
Check (untreated)	2					
			Granary weevil			
3	47	86	89	90	90	92
15	32	99	100			
30	71	98	99	100		
0 2/	7	10	21	21	34	34
Check (untreated)	1	19	19	23	23	25
			Confused flour beetle			
3	9	31	65	90	95	97
15	54	100				
30	89	100				
0 2/	1	4	9	9	12	13
Check (untreated)	1	1	2	2	2	4
			Lesser grain borer			
3	35	84	92	92	92	92
15	100					
30	100					
0 2/	13	27	28	31	31	31
Check (untreated)	11	20	30	30	38	62
			Saw-toothed grain beetle			
3	36	56	65	65	65	68
15	97	100				
30	100					
0 2/	10	31	44	45	47	51
Check (untreated)	10	13	15	15	19	81
			Cadelle			
3	0	10	40	50	50	80
15	40	60	80	90	90	90
30	60	70	80	90	100	
0 2/	10	10	10	10	10	90
Check (untreated)	0	0	0	0	0	0

1/ 100 insects were used in each of these tests, except with the cadelle in which case only 25 were used.

2/ Pyrophyllite (1,000 p.p.m.) without DDT.

To determine the influence of DDT when used in seed wheat containing more than 12 percent moisture, samples containing 14 and 16 percent moisture were treated with undiluted DDT at the rates of 0.05, 0.1, and 0.2 percent by weight. Each sample was artificially infested with 100 adults of the rice weevil, and set aside for 10 days. At the end of that time the mortality was complete in all samples. Subsequent observations showed no emergence of weevils from these samples, indicating that they died without having oviposited.

To determine whether DDT would have any effect on the germination of seed wheat, the viability of the treated samples was determined once a month for 4 months. As indicated in table 2, dosages as high as 0.2 percent by weight of DDT showed no injurious effects.

Table 2.--Effect of technical DDT on viability of seed wheat containing 12 percent moisture

Concentration of DDT, by weight	Germination of seed wheat after—			
	1 month	2 months	3 months	4 months
Percent	Percent	Percent	Percent	Percent
0.05	91	95	93	86
.1	91	88	90	90
.2	90	90	90	95
Check (untreated)	87	86	93	87

Tests with Packaged and Bulk Seeds

The success obtained with experiments on seed wheat led to more extensive tests with DDT for the prevention of insect damage to both bulk and packaged seeds of different kinds. Infestation in packaged seed, particularly by the Indian-meal moth, is always a problem when unused stocks must be held over the summer. Young larvae hatch from eggs laid by the moths on or near the packages of seed, and enter envelopes at the top corners where they are not completely sealed. After feeding on the seed until they attain their full growth, they cut their way out through the packets. Other troublesome insects are the flour beetles (Tribolium spp.), the saw-toothed grain beetle, and dermestids of the genera Trogoderma and Attagenus.

The seeds used in these tests were watermelon, corn, tomato, and lettuce in paper envelopes ranging from 1 ounce to 1 pound in size, and sunflower in bulk in cotton bags. All the seeds were treated with 0.05 percent of technical DDT, repackaged, and placed with untreated lots in a special screened metal cabinet. A supply of wheat heavily infested with the Indian-meal moth, the confused flour beetle, and the saw-toothed grain beetle had been placed in the bottom of the cabinet and covered with a screened false floor on which the various lots of seed were set. Insects from the infested wheat thus had an opportunity to enter the packages of seed. The cabinet was held in a constant-temperature chamber at 80° F. and a relative humidity of from 75 to 80 percent. At the end of 2 months the various lots of seed were removed and examined. The results are recorded in table 3.

Table 3.--Condition of seed containing 0.05 percent by weight of technical DDT after exposure to insect infestation for 2 months

Type of package and seed	Insect damage to package containing: Treated seed	Insect damage to package containing: Untreated seed	Insect damage to seed: Treated	Insect damage to seed: Untreated
In paper envelopes:				
Watermelon	None	None	A few dead insects. No damage.	Heavily infested with Indian-meal moth and confused flour beetle.
Corn	1 hole in envelope	None	A few dead insects. No damage.	Heavily infested with Indian-meal moth, confused flour beetle, and saw-toothed grain beetle.
Tomato	None	1 hole in envelope	No damage.	Infested with Indian-meal moth.
Lettuce	None	None	1 *Trogoderma versicolor* Creutz. larva alive.	No damage.
In cotton bag (bulk)				
Sunflower	None	None	A few dead insects. No damage.	Heavily infested with Indian-meal moth, confused flour beetle, and saw-toothed grain beetle. Damage to seed considerable.

Comparable results were obtained with a similar series of packaged seed exposed to possible infestation in the warehouse of a commercial seed dealer during the summer.

It is evident from table 3 that treatment of packaged and bulk seed with DDT at the rate of 0.05 percent by weight will give adequate protection from damage by most insects that infest seed. Dermestid larvae appear to be considerably more resistant to DDT than other insects. Possibly the dense coat of hairs covering the larvae prevents the dust from coming in contact with their bodies.

An objectionable feature of DDT as a seed treatment is its inability to repel the insects, but for the most part they are killed before any damage is done. Although no large-scale tests have been conducted with the 3 percent DDT-pyrophyllite mixture in packaged and bulk seeds, it seems probably that equally good results could be obtained by using the same dosage of the mixture as of the undiluted DDT.

Tests with DDT Sprays for Controlling Stored-product Insects

The elimination of infestations in the woodwork of grain bins, warehouses, storerooms, flour mills, and railway box cars has long been a serious problem. The cadelle causes a tremendous amount of damage by its habit of burrowing into such woodwork. It is extremely common in farm granaries, in railway box cars and in warehouses. This species and others survive for months in these burrows. When fresh grain is placed in farm bins it often becomes infested by great numbers of these insects emerging from the woodwork. Flour and other cereals in transit in infested box cars or in storage in warehouses are similarly invaded, and heavy losses have resulted from the spread of infestation from woodwork to grain and milled cereal products in storage or in transit. The cadelle will cut through almost any type of bag or container to reach the milled cereal products. The use of fumigants and ordinary contact sprays, although of some value, has never been entirely satisfactory in such cases. Experiments conducted during the past season indicate that the use of a DDT-oil spray may be the best means yet discovered for destroying infestations of these insects persisting in woodwork.

In the course of experimental work on the treatment of wooden farm granaries to eliminate infestations and to prevent grain-infesting insects from burrowing into the woodwork, the interior walls of some bins were sprayed with a refined odorless kerosene containing 6 percent of DDT. The solution was applied with a paint-spray gun at a pressure of 40 pounds per square inch. A few days after treatment the floors of the bins were littered with large numbers of dead adults and larvae of the cadelle. In one bin approximately 8,000 dead cadelles were swept from the floor at the base of 10 linear feet of sprayed wall. The killing action persisted for some time, since dying cadelles were emerging from the walls for weeks after the treatment.

The floors, walls, and partitions of storerooms and the lower floors of flour mills frequently harbor insects that invade flour, feed, or seed temporarily stored in such places. Spraying with a refined odorless kerosene containing 5 percent of DDT cleaned up an infestation of flour beetles in a wallboard partitition of a flour-storage room, and gave excellent results against silverfish infestations in a wheat-sample room and the first floor of a flour mill. Insects present in the sprayed areas were killed, and the residual effect caused the death of invading silverfish for many weeks after treatment.

DDT Treatment of Bags to Prevent Entrance of Stored-product Insects

In an earlier report 1/ it was stated that paper impregnated with a 10 percent solution of DDT in acetone offered great resistance to penetration by insects, and it was suggested that this repellent property might be used to advantage in the treatment of materials used to package milled cereal products.

In subsequent tests, bags were made of kraft paper that had been treated in three ways--(1) by dipping in a 10 percent solution of DDT in acetone, (2) by painting one side with varnish containing 10 percent of DDT, and (3) by coating one side with a standard clay coating liquor containing 10 percent of DDT. The bags were filled with flour, tightly sealed and exposed to a heavy infestation of the cadelle, the lesser grain borer, and the confused flour beetle. All the treated bags resisted penetration by these insects for many months, whereas bags made of untreated kraft paper were usually penetrated within a few days.

1/ Cotton, R. T., Balzer, A. I., and Young, H. D. The possible utility of DDT for insect-proofing paper bags. (Scientific Note) Jour. Econ. Ent. 37: 140. 1944.

Another test was conducted with ordinary cotton flour bags and with No. 5 kraft paper bags such as used in grocery stores. One series of bags was treated by spraying the outside with a 5 percent solution of DDT in carbon tetrachloride, and a second series was dipped in a similar solution. After aeration to allow the carbon tetrachloride to evaporate, 1 pound of uninfested flour was placed in each bag. The cloth bags were closed by tying the tops with string. The tops of the paper bags were glued, and then further sealed with Scotch Tape. The treated bags, together with the untreated checks, were placed in a metal tank containing grain heavily infested with cadelle larvae and confused flour beetle adults. After 1 month's exposure the bags were removed, the flour sifted, and a record made of any infestation. From the data in table 4 it is evident that considerable resistance to insect attack is imparted to both types of bags by impregnation with DDT. The greater infestation in the cloth bags is due to the ability of the insects to penetrate fabric more easily than paper.

Table 4.--Resistance of cotton and paper bags treated with 5 percent of DDT in carbon tetrachloride to infestation by stored-product insects

Type of package and treatment	Insects found in bags after 1 month			Number of holes in bag
	Flour Beetle		Cadelle	
	Adults	Larvae	Larvae	
Cotton cloth				
Spray, 5 ml.	7	1	20	1
	6	1	24	1
	3	0	17	3
Dip	7	0	4	0
	2	1	4	1
	4	0	8	1
Check (untreated)	37	99	51	20
Kraft paper				
Spray, 5 ml.	19	74	4	10
	0	0	0	0
10 ml.	0	0	0	0
Dip	0	0	0	0
	0	0	0	0
	0	0	1	1
Check (untreated)	93	206	15	48

In another test two 100-pound cotton bags, one treated by dipping in a 5 percent solution of DDT in carbon tetrachloride and the other untreated, were filled with flour and stored next to each other in a mill basement. In a few hours the untreated bag was literally covered with silverfish, whereas not a single insect was observed on the treated bag.